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To : Kathy Baskin, EEA

From : Stephen H. Kaiser, PhD

Comment #1 on Safe Yield for Water Management

The complexity of the Water Management issue warrants a very deliberate approach. I shall begin with a relatively concise initial comment. My goal is to assemble empirical evidence that will improve the accuracy and credibility of safe yield calculations.

Several observers have contended that the safe yield calculations released to date are too high. They assert that recent safe yield proposals will result in potential additional allocations for many highly stressed rivers. I agree with much of this criticism.

At the February 17 Technical Committee meeting, I became concerned that the safe yield results developed so far have been based on a simulation. There were no "models" and no calibration. The only evident verification occurred in comparison to 1965 annualized flows, not to specific daily drought flows.

Furthermore, I realized that the most needed number in the state's work to date is a calculation showing how future permitting action could bring about the drying up of river channels. We need to know whether or not safe yield will provide any real protection for our rivers. Otherwise, will the real protection come from streamflow criteria ?

My approach will be to provide two calculations :

1. The maximum safe yield that can be allowed for any watershed or sub-basin without drying up river and stream channels, and

2. The necessary flow that should remain in the rivers during drought conditions to provide the objectives of an Environmental Protection Factor.

The methodology will be strictly empirical. It will deal with existing measured flows, and actual withdrawals. The result will be a safe yield figure with a minimal chance of zero flow in the river.

FOCUS ON A SINGLE WATERSHED : THE PARKER RIVER

For this first comment, I have chosen to concentrate on one watershed, not twenty eight. My focus will be on the Parker River basin generally and the Byfield gage sub-basin in particular. There is a USGS gage at Byfield near Route I-95. It covers the upper 1/4 of the total Parker Watershed, with a record of continuous flow measurements since 1945. Evaluation of the Byfield sub-basin is simplified because of the absence of reservoirs that might complicate safe yield estimates.

DROUGHT HISTORY OF THE PARKER RIVER

The Parker River flows at the Byfield USGS gage show us that the 1960s drought was <u>not</u> the historical worst drought year. Flows in 1963 set a drought record of 0.11 cfs. The current record drought occurred only 18 months ago, with the official measured flow dropping to 0.02 cfs in August 2010. Gage readings stayed near zero for three weeks.

The entire year 2010 was a strange combination of erratic rainfall. March 2010 produced a series of large storms with near-record floods. From February 25 through April 7 the river flow never dropped below 166 cfs.

The following eight to nine months produced a plunge into record drought, extending through the summer and into the fall. Reduced rainfall began in April. Within one month, river flows dropped by a factor of ten to 17 cfs in early May 7. By June, flows dropped to 7.2 cfs, then 0.52 cfs in early July, and finally 0.06 cfs in early August. The river was virtually dry for three weeks in August ... only five months after major flooding.

River flow recovered very slowly in September, and thereafter took quite a while returning to normal by January or February of 2011. The river had been beset by a sudden and fierce drought, with the very-low-flow period lasting for five months. Not until March 1, 2011 did flows rise above 70 cfs. The Parker River spiraled from near-record floods to a record drought -- all in one year.

Modern rivers tend to follow a fairly common pattern, with record high and low flows occurring in more recent years. There is evidence that this situation is largely due to the growth in impermeable land areas. Faster runoff has prevented the vital replenishment of ground water. For the Parker River, USGS data has shown that annual runoff in 2009 was 35.1 inches, a significant increase over the 1946-2009 average runoff of 24.4 inches.

The pressure for water withdrawal continues unabated. Both Georgetown and Byfield have exceeded their permitted withdrawal levels in recent years. Georgetown has three wells upstream of the Byfield gage, all hydraulically close to the Parker River.

WORKING WITH SUB-BASINS FOR ALL PERMITTING ACTIONS

When rivers dry up, such events usually occur in the upper reaches of a watershed. Except for the Colorado River, flows at the estuary tend to be much more robust that in the upper reaches of rivers. Small sub-basins can suffer from large upstream water withdrawals.

This scenario accurately describes conditions in the reaches upstream of the Byfield gage on the Parker River, and for certain upstream branches of the Ipswich and Jones Rivers. It would have been most useful during the SWMI process to have a map of rivers and streams that have been dried up in the past two decades.

The implications for safe yield should be made very clear -- that when evaluations are made of safe yield for a water withdrawal, it must be done for a sub-basin. And that sub-basin is defined by the physical location of withdrawal. In practice DEP would need to identify the correct sub-basin area on a reduced or prorated basis -- proportional to the total basin area.

DESIGN of a NEW FLOW GAGE MODEL

My goal will be to calculate an empirical safe yield for the Byfield gage sub-basin. I will utilize USGS gage data for low flows during the 2010 drought. The focus will be on an August drought condition that is intentionally non-annualized and uses average August water consumption. Such usage will reflect the seasonal trends for local uses in August, and not yearly averages.

From this Byfield safe yield, I will factor up the safe yield proportional to the basin areas to obtain a safe yield for the entire Parker watershed. The Byfield sub-basin at 21.3 square miles is 26% of the area of the total 81.8 square mile Parker watershed. The average annual use is calculated from the 2.3 MGD figure for the whole watershed, which translates to 0.60 MGD or 0.93 cfs at the Byfield gage.

To obtain the average August usage, I referred to Georgetown's water pumping reports for 2009. This data shows that August usage rates are 39 percent higher than the annual average. I applied this same adjustment to the basin and sub-basin. The average August water use for the Byfield sub-basin was 1.29 cfs. During the first three weeks of August 2010, the gage readings averaged about 0.06 cfs, from which I calculated the effective sub-basin safe yield at that drought time to be 1.35 cfs.

Translating these figures to the entire Parker basin, the Drought Safe Yield is 5.18 cfs or 3.35 MGD. By comparison the annualized safe yield of SWMI is 14.80 MGD. The annualized result is 4.4 times larger than the gage flow model -- based on actual August drought conditions.

The last step in the process was to apply an Environmental Protection Factor similar to the concept used by SWMI. The EPF assigned by SWMI is about 82 percent of the safe yield or the ratio of 0.45 to 0.55. For a Byfield safe yield of 1.35 cfs, the EPF would be 1.10 cfs at Byfield and 4.24 cfs for the entire watershed. In an August drought, the total river flow would be the sum of historic flood flow (0.06 cfs) and the EPF, or 1.16 cfs. This flow represents a summer drought condition with the environmental protection flow included.

The environmental protection factor may include other concerns beyond restoration of the aquatic environment. Some other benefits are accounting for a safety factor when risk is uncertain .... or for unpredictably severe future conditions ... or for inevitable errors in computer modeling, including undue optimism.

In practice, the necessary Environmental Protection flow can be achieved in several different ways. One is through water conservation measures, especially from July to October. Another is to drill a bedrock well that is distant from the river and that will be less likely to draw down the river. A third option is an interbasin transfer, such as water from the nearby Merrimack River. For the Parker, a fourth option is largely theoretical : reservoir storage -- such as MWRA does with the brilliant Ware River intake, its skimming of spring flood waters, and redirecting the water to Quabbin for storage and eventual delivery back to Boston. However, springtime skimming of the Parker to replenish local groundwater levels could be considered.

CONCLUSION :

The empirical concept I have presented as the gage flow model appears to offer more realistic protections for stressed rivers like the Parker, and avoids problems with annualized drought methods. I will discuss in a future comment how annualized flows tend to produce unduly high safe yields and could lead to subsequent new and unjustified withdrawals.

The safe yield of the Parker basin is 3.35 MGD, and there is a flow of 1.16 cfs in the river at Byfield for even a severe drought day. The river is restored. It does not dry up on a severe drought day and retains a flow of over 1 cfs.

The state should consider revising its models to concentrate on peak day drought events. The environmental agencies should abandon annualization and other methods that do not accurately represent low-flow conditions observed in some of our rivers in recent years.

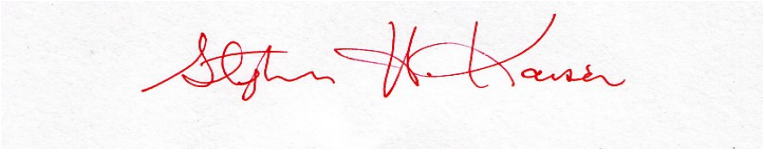
Our models must account for seasonal variations in both yield and user demand. They should be focused on drought years with low flows in August, September and October.

In future comments, I hope to extend the gage flow analysis to other key basins, including the Ipswich, Charles, Jones and Westfield Rivers. The use of annualized flow numbers in calculating safe yield needs a more detailed discussion. We also need a legal perspective on how to deal with the awkward wording and structure of Chapter 21G and how to resolve the administration of water management in a legally compliant way. Finally we need to recognize water management as another application of the Tragedy of the Commons. Similar issues have bedeviled us such as ocean fishing, forestry on state land, invasions of state lands by noisy uses such as ATVs and motorcycles, and that old standby : the traffic jams on our "free" roads that never seem to go away but just get shifted from place to place.

I would like to recognize the gradually increasing success of the participatory process associated with the SWMI program. The circulation of spreadsheets has -- for some of us at least -- provided insight into how the state is proposing to deal with everything from safe yield, reservoirs, and drought. At the same time officials must administer a process dealing with fish populations, applicable statutes, and a long history of unresolved frictions and conflicting policy interpretations dating back a quarter of a century. My view may be a solitary one, but I think the long sabbatical that the formal process took last year may have given many of us time to think and reflect on the issues. There seems to have been a certain newness and freshness in restarting the effort in January.

I also have the sense from the commitment of personnel and resources that EEA has decided to resolve the water management issue once and for all. Twenty-five years is a long time and a long wait for many advocates of the health of our rivers, and a credible resolution of the matter would be most welcome.

Sincerely,



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Attachment : spreadsheet file -- "Safe Yield Calculation for Parker River based on Gage Flow"